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Evaluation of safety of water resource in Henan province and safeguard measures

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ABSTRACT

Water resource is distributed unevenly in Henan province both chronologically and spatially with inadequate storage, increasingly high demand, low utilization degree, large consumption and severe pollution. This paper is mainly to solve the problems on water resources security guarantee mechanism. The significance of solving such problems is to alleviate the insufficient situation of supply and demand of water resources in Henan province. The core innovation is to evaluate the safety status of water resource in Henan province. Compared with previous work, the research adopts the methodology of fussy comprehensive evaluation and the results show that water resource in Henan province is unsafe. Hence, reasonable safeguarding system for water resource shall be established on the basis of agricultural and industrial development, urban construction and industrial restructuring to develop water saving technology, adjust industrial structure, ease water pollution, increase water storage and protect water quality.

KEYWORDS

Henan province; Safety of water resource; Fussy comprehensive evaluation; Water pollution.

GENERAL INTRODUCTION OF WATER RESOURCE IN HENAN PROVINCE

Henan province is located in the Southern temperate zone on the North and the Northern subtropical zone on the South with the Funiu Mountains and the Huaihe River as dividing lines. The climate has apparent transition with winter having little precipitation and often controlled by high pressure air mass. In summer where westerlies and subtropical zone overlap, it rains abundantly and changes dramatically with frequent occurrence of flood and storm. Hence, it could be seen that water resource is distributed unevenly in Henan province both chronologically and spatially.

The topography of Henan province is in the shape of terrace going lower from the West to the East with the West, the South and the Northwest higher than the East and the North. The terrain goes from mountains of medium and low height to hills and plains and with narrow hilly area, the province has weak buffer capacity against floods from mountains and highly vulnerable to floods in plain area. The mounds and plateaus in Henan province which are usually deep and sleep are higher than water level, resulting in inadequate conditions for water storage and reservation and easily causing drought. Hence, the distribution of water resource in Henan province is uneven in terms of space.

Henan province passes four great rivers, namely the Yellow River, the Yangtze River, the Haihe River and the Huaihe River, and nine branches have drainage area over 10,000 square kilometers respectively. The rivers are mostly wide in the upper reaches and narrow in the lower, giving unfavorable conditions for draining flood and waterlog water.

Soil in Henan province is mostly gravel black soil and silty soil. Gravel black soil which is rich in calcium carbonate is sticky and dense with bad water permeability. It swells in water and contracts when dry. In the case of rainy days for long time, water stays in the soil, which could easily result in surface water logging. Being sticky and dense, the gravel black soil has bad water permeability and could not breathe air easily, easily causing inundation with heavy rain.

In a word, the distribution of water resource in Henan province is uneven in terms of both chronology and space. The rivers therein could not easily drain water logging and flood and the soil therein could not preserve soil easily, all constituting unfavorable factors to safeguard safety of water resource.

CURRENT CONDITIONS OF WATER RESOURCE IN HENAN PROVINCE

Current gross amount of water resources

The average precipitation of Henan province in 2012 amounted to 605.2mm, down by 21.5% in comparison with the average amount for the previous years. Precipitations in the drainage areas of the Yellow River, the Yangtze River, the Haihe River and the Huaihe River within the administration of Henan province amounted to 488.6mm, 667.7 mm, 491.5 mm and 654.2 mm respectively, down by 22.8%, 18.8%, 19.4 % and 22.3% respectively in comparison with the average precipitations for the previous years. Ground water resource and gross amount of water resource of Henan province in 2012 totaled 17.27 billion and 26.65 billion m^3 respectively, 43.2% and 19.0% less than the respective average amounts for the previous years. Water storage of 22 large reservoirs and 104 medium reservoirs in Henan province in 2012 was 4.780 billion m^3, down by 928 million m^3 than that in the previous year. Moreover, level of shallow ground water for Henan province in 2012 went down by 0.63m in comparison with the previous year and storage of ground water therein down by 1.99 billion m^3. Total area of the funnel areas in shallow ground water in plain area of Henan province has accounted for 8.8% of total plain area therein, up by 114 km^2 than that in the previous year.

Based on the data here above, it could be seen that water storage in Henan province is going down and there is downward pressure from precipitation, ground water storage and storage capacity of reservoirs.

Current gross water consumption

Gross water consumption of Henan province in 2012 reached 23.861 billion m^3, up by 967 million m^3, which is 4.2%, than that in the previous year. Water for the primary industry (agriculture, forestry and fishing industry), industrial use and general uses in rural and urban areas (for living, environment and other general uses) of Henan province in 2012 amounted to 13.003 billion, 6.05 billion and 4.806 billion m^3 respectively, accounting for 54.4%, 25.4% and 20.1% of the gross water consumption therein respectively. Since the year of 2012 is nearly a drought year, amount of agricultural water was relatively higher, up by 542 million m^3 than the previous year, industrial water went up by 370 million m^3 and water for general uses rose by 44 million m^3. With difference in water sources, distribution of rainfall, industrial structure, living standard and economic development status in different cities of Henan province in 2012, water consumption and water structure differ in different cities as well. In cities like Kaifeng, Anyang, Hebi, Puyang, Xinxiang, Zhoukou, Shangqiu, Xinyang and Zhumadian, relatively larger proportion of water, over 60% has been used for agriculture, forestry and fishing industry; whereas, in such cities as Zhengzhou, Luoyang, Pingdingshan, Jiaozuo, Xuchang, Luohe, Sanmenxia, Nanyang and Jiyuan, the proportion of water for industrial use is larger, exceeding 25% of gross water consumption.

Based upon the data here above, it could be learnt that as industrialization, urbanization and agriculture modernization deepen, the demand for water resource in Henan province rises rapidly no matter from agriculture, industry or urbanization. Among the three sectors here above, the largest demand for water is from agriculture, followed by industry and general uses.

Current utilization of water resources

Utilization degree of water resource could be demonstrated by control and utilization rate of ground water resource, the larger the better, by utilization and consumption rate of gross water resource, the lower the better, and by exploitation rate of shallow ground water in plain area, the larger the better. The three rates here above for Henan province amount to 28.4%, 41.6% and 72.9% respectively. Refer to table 1.

Table 1 : Utilization degree of water resources in Henan province in 2012 in different drainage areas

Drainage area	The Haihe River	The Yellow River	The Huaihe River	The Yangtze River	Entire province
Control & utilization rate of ground water (%)	27.9	50.2	25.3	17.6	28.4
Utilization and consumption rate of gross water resource (%)	76.6	49.4	41.3	21.9	41.6
Exploitation rate of shallow ground water in plain area (%)	76.6	69.3	63.6	82.1	72.9

As table 1 demonstrates, Henan province possesses lower control and utilization rate, higher utilization and consumption rate and the exploitation rate for shallow ground water in plain area could be improved.

Current consumption status of water resource

The gross water consumed in Henan province in 2012 amounted to 13.451 billion m^3, accounting for 56.4% of gross amount of water resource therein, among which water consumed by primary industry, industry and general use accounted for 67.6%, 10% and 22.4% respectively. The average consumption rate of water resource in the entire province was 56% and the rates for the primary industry, industry and general uses accounted for 69.9%, 22.2% and 62.7% respectively.

Consumption rate refers to the amount of water consumed during distribution yet unable to return to ground water or underground aquifers in form of evaporation, soil absorption, product consumption, drinking by residents and livestock. With consumption rate as an important index for level of water utilization, it could be seen from the data here above that the utilization rate of water resource in Henan province is still at low level, needing to be improved.

Current pollution status of water resource

Monitor over water quality and evaluation hereof have been conducted to 443 water sources of 128 major rivers in the entire province. As the results show, rivers with water quality reaching or exceeding Grade III standard account for 39.4% of all the rivers in the province in terms of length; rivers with water quality of Grade IV and V, standard for industrial and agricultural water, account for 15.9% thereof and polluted rivers worse than Grade V and losing water supply capacity account for 35.3% thereof. Evaluation has been conducted to 356 ground water functionality districts in Henan province in 2012 with 22.3% districts satisfying related standards. Total evaluated water sources were 9930.5 km in length, 22.3% satisfying related standards. The evaluated reservoirs require 3.34 billion m^3 water in total, 62.5% satisfying related standards.

Based on the data here above, it could be learnt that the quality of water resource in Henan province is not favorable with river water seriously polluted. According to data declared by United Nations, a district has touched the warning line of water shortage with average water resource per capita of only 1000 m^3 and it is in serious shortage of water with average water resource per capita of only 500 m^3[1]. The average water resource per capita and per mou of Henan province amount to 254 m^3 and 167 m^3 respectively, showing that Henan province is in serious shortage of water.

EVALUATION OF SAFETY OF WATER RESOURCE IN HENAN PROVINCE BASED ON FUSSY COMPREHENSIVE EVALUATION

Fussy comprehensive evaluation is an effective decision method based upon multiple factors to conduct comprehensive evaluation of a matter that is influenced by a great many factors. Fussy subaggregates are established to quantify the fussy index of the evaluation object. Next, fussy transformation principles are employed to conduct comprehensive evaluation of each individual index. The evaluation process here above could be generalized into the following steps [2, 3].

a. Establishment of factor aggregate: $U = \{u_1, u_2, ..., u_n\}$. Where n refers to number of evaluation factors;

b. Determination of evaluation aggregate: $V = \{v_1, v_2, ..., v_n\}$, an aggregate representing evaluation grade and classification, where each grade corresponds to a fussy aggregate.

c. Establishment of subaggregates and fussy relation matrix: Establishment of subaggregates, key in application of fussy mathematics, could help determine subordination degrees of actual values of different factors, evaluate single factor and establish fussy relationship matrix.

$$R=\begin{bmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{bmatrix} \quad (1)$$

Where r_{ij}, u_i and j refer to the factor numbered i, evaluation aggregate numbered u_i and subordination degree graded j.

d. Determination of weighted fussy vector: Considering different effects of evaluation factors on safety of water resource during comprehensive evaluation, the fussy vector $\omega=\{a_1,a_2,\cdots,a_n\}$ shall be determined before combination, where a_i essentially is subordination degree of factor u_i to fussy aggregate. The determination method shall be selected in accordance with the principle that the factor having more effects on the safety of water resource has larger weight (the principle of highest subordination).

e. Fussy comprehensive evaluation: Comprehensive evaluation is based upon weights of different factors and the principle of fussy transformation. For ω, max-min is utilized for synthesis, which gives comprehensive evaluation by $P=\omega\cdot R$.

Index system and grading standards for safety evaluation

(a) Establishment of index system for safety evaluation

The index system is established upon the principle of being scientific, comprehensive and practical and after consideration of actual conditions of Henan province. Accordingly, 17 index have been selected from three aspects, namely social security, economic security and ecological safety, for the objective of evaluating safety of water resource in Henan province. In terms of social security, four index have been selected, including water amount per capita, percentage of the population having safe drinking water, domestic water consumption per capita in rural and urban area. Regarding economic security, seven index have been selected, namely GDP per capita, Rate of repeated water utilization of industrial enterprise, urbanization rate, efficiency coefficient of irrigation water, effective irrigation area per capita, water consumption of industrial value per 10,000 Yuan, and percentage of domestic water expense in disposable family income. Of ecological safety, six index have been selected, inclusive of dilution ratio, sewage treatment rate, ground and underground water quality, proportion of hydraulic investment in GDP and green area per capita. The index system for safety evaluation of water resource in Henan province is indicated in table 2 below.

Table 2 : Index system for safety evaluation of water resource in Henan province

Safety of water resource (A)	Social security (B_1)	water amount per capita (B_{11})(m^3)
		percentage of the population having safe drinking water(B_{12})(%)
		domestic water consumption per capita in rural area(B_{13})($L\cdot d^{-1}$)
		domestic water consumption per capita in urban area(B_{14})($L\cdot d^{-1}$)
	Economic security (B_2)	GDP per capita (B_{21})(Yuan)
		Rate of repeated water utilization of industrial enterprise (B_{22})(%)
		urbanization rate (B_{23})(%)
		efficiency coefficient of irrigation water (B_{24})(%)
		effective irrigation area per capita (B_{25})(mou/person)
		water consumption of industrial value per 10,000 Yuan(B_{26})(m^3)
		percentage of domestic water expense in disposable family income (B_{27})(%)
	Ecological safety (B_3)	dilution ratio (B_{31})(%)
		sewage treatment rate (B_{32})(%)
		ground water quality (B_{33})
		underground water quality (B_{34})
		proportion of hydraulic investment in GDP (B_{35})(%)
		green area per capita (B_{36})(m^2)

(b) Data of safety of water resource of Henan province in recent period

The basic information of water resource of Henan province is shown in table 3.

Table 3 : Safety index of water resource of Henan province

Name of index	Data
water amount per capita (m^3)	349
percentage of the population having safe drinking water (%)	72.49
domestic water consumption per capita in rural area ($L \cdot d^{-1}$)	83
domestic water consumption per capita in urban area ($L \cdot d^{-1}$)	206
GDP per capita (Yuan)	28661
Rate of repeated water utilization of industrial enterprise (%)	86.59
urbanization rate (%)	40.60
efficiency coefficient of irrigation water (%)	57
effective irrigation area per capita (mou/person)	0.7161
water consumption of industrial value per 10,000 Yuan (m^3)	39
percentage of domestic water expense in disposable family income (%)	0.4
dilution ratio (%)	35
sewage treatment rate (%)	85
ground water quality	0.809
underground water quality	0.708
proportion of hydraulic investment in GDP (%)	0.012
green area per capita (m^2)	11.2

(c) Gradings and standard values of safety of water resource of Henan province

The grading in the research could be obtained by $V = \{v_1, v_2, ..., v_5\}$, where v_1=absolutely safe, v_2=generally safe, v_3=safe, v_4=unsafe, v_5=highly unsafe. See table 4.

Table 4 : Gradings and standard values of safety of water resource of Henan province

Name of index	v_1	v_2	v_3	v_4	v_5
water amount per capita (m^3)	≥1000	750~1000	500~750	250~500	<250
percentage of the population having safe drinking water (%)	≥100	90~100	80~90	70~80	<70
domestic water consumption per capita in rural area ($L \cdot d^{-1}$)	≥160	120~160	80~120	40~80	<40
domestic water consumption per capita in urban area ($L \cdot d^{-1}$)	≥200	160~200	120~160	80~120	<80
GDP per capita (Yuan)	≥17500	13950~17500	10400~13950	6850~10400	<6850
Rate of repeated water utilization of industrial enterprise (%)	≥85	75~85	65~75	55~65	<55
urbanization rate (%)	≥60	50~60	40~50	30~40	<30
efficiency coefficient of irrigation water (%)	≥0.6	0.5~0.6	0.4~0.5	0.3~0.4	<0.3
effective irrigation area per capita (mou/person)	≥1	0.83~1	0.66~0.83	0.5~0.66	<0.5
water consumption of industrial value per 10,000 Yuan (m^3)	<30	30~80	80~130	130~180	>180
percentage of domestic water expense in disposable family income (%)	<1	1~1.6	1.6~2.3	2.3~3	≥3
dilution ratio (%)	<3.2	3.2~5.5	5.5~7.7	7.7~10	≥10
sewage treatment rate (%)	≥80	60~80	40~60	20~40	<20
ground water quality	≥0.9	0.75~0.9	0.60~0.75	0.45~0.60	<0.45
underground water quality	≥0.95	0.9~0.95	0.85~0.9	0.8~0.85	<0.8
proportion of hydraulic investment in GDP (%)	≥1	0.74~1	0.47~0.74	0.2~0.47	<0.2
green area per capita (m^2)	≥14	10~14	6~10	2~6	<2

Weights of evaluation index

In fussy comprehensive evaluation, weights of different index are of important significance, which indicate roles of index in comprehensive decision and influence the evaluation results directly. Analytic hierarchy process (AHP) is employed in the research to determine weights of different index [3].Pairwise comparison matrix has been established, single layer weight vectors calculated and consistency among matrix examined to obtain the results shown in table 5.

Table 5 : Examination results of consistency of pairwise comparison matrix

Matrix	Weight vector	λ	CR
$A-B_i$	$(0.5390, 0.2972, 0.1638)$	3.0092	0.0079
B_1-B_{1j}	$(0.5423, 0.2333, 0.1397, 0.0847)$	4.0521	0.0192
B_2-B_{2j}	$(0.3197, 0.2331, 0.1576, 0.0944, 0.0944, 0.0504, 0.0504)$	7.1091	0.0137
B_3-B_{3j}	$(0.3409, 0.2054, 0.2054, 0.1226, 0.0761, 0.0496)$	6.0722	0.0116

Fussy comprehensive evaluation

(a) Determination of subordination degrees of evaluation index

The key of application of fussy mathematic method is to establish reasonable membership function. In this research, fussy treatment has been employed to establish triangular membership function and in order to ensure smooth transition among different grades, midpoint of individual grading section is adopted as dividing point. In the case that the index value is the midpoint of a section, the subordination degree is regarded as 1. In the case that the index value is the midpoint of neighboring section, the subordination degree is 0. Membership function is established to determine subordination value of different index and the results are shown in table 6.

Table 6 : Subordination degrees of different index

Name of index	Subordination degree
water amount per capita (m^3)	(0, 0, 0, 0.896, 0.104)
percentage of the population having safe drinking water (%)	(0, 0, 0, 0.749, 0.251)
domestic water consumption per capita in rural area ($L \cdot d^{-1}$)	(0, 0, 0.575, 0.425, 0)
domestic water consumption per capita in urban area ($L \cdot d^{-1}$)	(0.65, 0.35, 0, 0, 0)
GDP per capita (Yuan)	(1, 0, 0, 0, 0)
Rate of repeated water utilization of industrial enterprise (%)	(0.659, 0.341, 0, 0, 0)
urbanization rate (%)	(0, 0, 0.56, 0.44, 0)
efficiency coefficient of irrigation water (%)	(0.2, 0.8, 0, 0, 0)
effective irrigation area per capita (mou/person)	(0, 0, 0.85, 0.15, 0)
water consumption of industrial value per 10,000 Yuan (m^3)	(0.32, 0.68, 0, 0, 0)
percentage of domestic water expense in disposable family income (%)	(1, 0, 0, 0, 0)
dilution ratio (%)	(0, 0, 0, 0, 1)
sewage treatment rate (%)	(1, 0, 0, 0, 0)
ground water quality	(0, 0.893, 0.107, 0, 0)
underground water quality	(0, 0, 0, 0, 1)
proportion of hydraulic investment in GDP (%)	(0, 0, 0, 0, 1)
green area per capita (m^2)	(0, 0.8, 0.2, 0, 0)

(b) Establishment of fussy relation matrix

Based on table 6, fussy relationship matrix for the three subsystems could be obtained, inclusive of subsystem of social security, economic security and ecological safety.

For subsystem of social security

$$R_1 = \begin{pmatrix} 0 & 0 & 0 & 0.896 & 0.104 \\ 0 & 0 & 0 & 0.709 & 0.251 \\ 0 & 0 & 0.575 & 0.425 & 0 \\ 0.65 & 0.35 & 0 & 0 & 0 \end{pmatrix} \quad (2)$$

For subsystem of economic security

$$R_2 = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.659 & 0.341 & 0 & 0 & 0 \\ 0 & 0 & 0.56 & 0.44 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 \\ 0 & 0 & 0.85 & 0.15 & 0 \\ 0.32 & 0.68 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{pmatrix} \quad (3)$$

For subsystem of ecological security

$$R_3 = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0.893 & 0.107 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0.8 & 0.2 & 0 & 0 \end{pmatrix} \quad (4)$$

(c) Evaluation results

a. Evaluation results for different subsystems are given below.

For subsystem of social security

$$P_1 = \omega_1 \cdot R_1 = (0.0550, 0.0296, 0.0803, 0.7199, 0.1149) \quad (5)$$

For subsystem of economic security

$$P_2 = \omega_2 \cdot R_2 = (0.5587, 0.1893, 0.1650, 0.0835, 0) \quad (6)$$

For subsystem of ecological security

$$P_3 = \omega_3 \cdot R_3 = (0.2054, 0.2231, 0.0319, 0, 0.5396) \quad (7)$$

b. Fussy comprehensive evaluation results of safety of water resource in Henan province

Weight vectors of different subsystems are: $\omega = (0.5390, 0.2972, 0.1638)$

Fussy relationship matrix:

$$R = \begin{pmatrix} 0.0550 & 0.0296 & 0.0803 & 0.7199 & 0.1149 \\ 0.5587 & 0.1893 & 0.1650 & 0.0835 & 0 \\ 0.2054 & 0.2231 & 0.0319 & 0 & 0.5396 \end{pmatrix} \quad (8)$$

Comprehensive evaluation result:

$$P = \omega \cdot R = (0.2293, 0.1088, 0.0975, 0.4128, 0.1503) \quad (9)$$

Based on the results here above, it could be seen that subordination degrees to unsafety and safety of water resource in Henan province are 0.5631 and 0.4369 respectively. Hence, water resource in Henan province is generally in unsafe status.

SAFEGUARD MEASURES AND POLICIES FOR WATER RESOURCE IN HENAN PROVINCE

With water as source for life and substances, the harmony between man and nature could only be realized by harmony between man and water resource, which ensures normal function and development of human life and social economic activities. For the objective of developing Henan province as ecological city, current unsafe conditions of water resource shall be changed, water resource be conserved, and waste hereof and pollution hereto be reduced. Meanwhile, normal water resource shall be developed actively and supply and provision of water resource be increased by attaching equal importance to development and conservation; therefore, a win-win situation could be realized between ecological protection and economic growth.

Conservation of agricultural water

As a major agricultural province, Henan province has large demand for water resource to ensure its agricultural activities which consume 60% of its gross water amount. Hence, conservation of agricultural water is key to realize water safety. Agricultural water shall be conserved through development of water saving technology and integrated use of water manure, spray and micro irrigation so that water loss could be effectively reduced and water keeping capacity of soil be improved. Meanwhile, plantation structure shall be optimized, crops with higher added value but consuming less water be developed in priority, crops using a great amount of water be restricted and breeds with high yield, good quality and drought tolerance be encouraged to be planted in large area[4,5].

In the course of development of water saving technology and adjustment of plantation structure, management for agricultural water and monitor hereto shall be enhanced as well. Monitor shall be exercised over pollutants above the land (fertilizers and pesticides) and over excrements of livestock and fowls [5]. Consumption of agricultural water shall be put under strict control through reasonable determination of irrigation water quota, improvement of metering facilities and clear identification of protection and management body of water saving works. Related responsibilities shall be identified; individuals and groups with good performance on water conservation shall be rewarded while responsibilities shall be looked into in accordance with laws and legislations with regard to behaviors of destroying water saving facilities or breaking water using regulations.

Conservation of industrial water

With development of industrialization and urbanization in Henan province, the demand for water resource in Henan province becomes increasingly large to meet requirements for industrial development and urban expansion, accounting for 25% of gross amount of water resource in Henan. From this perspective, in the course of improvement of industrial production in Henan, great attention shall be given to development of water saving industry, improvement of utilization rate of water resource and elimination of technology with high water consumption. Moreover, water saving technology and equipment shall be used in larger area, which include repeated use of industrial water, highly efficient cooling technology, water saving by heating and washing techniques, provision and treatment of industrial water, abnormal utilization of water resource and other general water saving technologies and production methodologies.

Management shall be enhanced for quota for taking water in major fields and state quota standards for water taking be implemented in strict compliance. Industrial projects with huge water consumption shall be controlled strictly and industrial structure and layout be adjusted reasonably for optimized allocation of water resource. More efforts shall be made to promote repeated use of enterprise water and recycled use of industrial sewage so that utilization rate of water resource could be improved and unit water consumption of products be reduced. In addition, the abnormal use of water resource shall be enhanced; take the development and use of rain and reclaimed water, supportive conditions shall be created for enterprise to reserve rain for later use [6].

Conservation of water for urbanization construction

As urbanization proceeds with irresistible momentum in Henan province, there appear a great many new residential areas and industrial parks, whose construction shall be planned in the long run to realize sustainable development of water resource. The construction of sewage treatment plants shall be accelerated in cities, domestic sewage in cities and towns be monitored and collected, and recycled use of sewage be realized through treatment plants. Treated sewage could be utilized for implementation of municipal works, construction of infrastructure facilities and for other purposes so that the contradiction between supply of and demand for water resource could be eased.

Water saving neighborhoods shall be developed with use of water saving public facilities and appliances. Water shall be used by quota and reclaiming system shall be available. Water saving industrial park shall be established to facilitate concentration of industries; in this way, water could be supplied, managed and sewage treated overall on one hand and water could be reclaimed to reduce water consumption indirectly on the other hand.

Water provision mains and networks in many cities of Henan province are old, resulting in loss of water resource once the pipelines are broken. Hence, precautionary measures shall be taken by public affairs departments. Old facilities, mains and networks shall be eliminated, mains and networks be altered, repaired and maintained, and leaking thereof be monitored with complete monitor equipment. Hence, on the basis of guaranteeing basic demand for water in cities, the pressure inside pipelines and the damages thereof could be reduced.

Optimization of industrial structure for reasonable allocation of water resources

Henan province has been increasingly restricted by the resource environment therein in recent years with unfavorable safe conditions of water resource. The conventional development mode is hard to proceed and industrial structure needs to be adjusted to cater for sustainable development of local economy. In terms of industrial restructuring, industries with low energy and water consumption but high added value shall be encouraged and industries with large energy consumption, severe environmental pollution and low yield be restricted or eliminated. With regard to adjustment of the proportions of the primary, secondary and tertiary industries, great efforts shall be made to develop the tertiary industry with low energy consumption and consumption of water shall be reduced through adjustment of industrial structure.

Alleviation of water pollution for protection of water quality

Two aspects shall be emphasized in prevention and treatment of water pollution, protection of water source and prevention and treatment of water pollution in drainage areas of major rivers. Information of water environment shall be published timely by the environmental protection department which is responsible for accuracy, timeliness of the information and for quality of water environment and prevention and treatment of water pollution [4].

Capacities for monitoring and evaluating drinking water sources shall be enhanced to improve monitoring and management capacities. Environment protection shall be stepped up for drinking water sources and related regulations and rules be implemented in strict compliance in Grade I and II protection zones. Constructional projects and activities against laws shall be eliminated and projects against laws shall be prohibited so that water quality at sources could be safeguarded.

Projects with large consumption of and serious pollution to water shall be restricted strictly, environmental protection check shall be exercised over industries with serious pollution and involving heavy metals, monitor and information thereof declared to public and clean production be promoted in major industries. In addition, enterprises satisfying requirements of environmental protection laws and legislations shall be encouraged and self check of clean production be encouraged in enterprises whose sewage has satisfied state and local discharge standards for pollutants.

Increase water reserve and reduce water risks to improve utilization rate of water resource

With uneven spatial distribution of water resources in Henan province, Henan province suffers from frequent drought disasters. Hence, great efforts shall be made to the following works, including repair and rehabilitation of works destroyed in water disasters, reinforcement of weak aspects of fight system against droughts and floods, alteration of large and medium irrigation and draining facilities, construction of Five Minor Hydraulic Works, implementation of efficient and water saving irrigation projects, safeguard of safety of drinking water in rural areas, water and soil preservation and water ecological construction. In this way, water resource could be conserved, protected and allocated reasonably, water provision security be safeguarded in rural and urban areas, and sustainable utilization of water resource be promoted.

Farmland water conservancy shall be enhanced. More efforts shall be made to enhance agricultural irrigation system and rehabilitate soil and water ecological system through development of irrigation area exceeding 10000 mou and increase of effective irrigation area. In addition, water for civil use shall be enhanced together with allocation works of water resource. Water network composing of rivers, lakes and reservoirs shall be established to improve adjustment capacity for water resource comprehensively. Moreover, efforts shall be made to enhance prevention against droughts and water loggings to alleviate the losses therefrom. Tending activities related with hydraulic works shall be monitored and the related laws and legislations be implemented in strict compliance. Treatment to water ecology shall be enhanced, protection therefore be improved and rehabilitation thereof stepped up, which includes protection of aquifers and wetlands. More efforts shall be made to soil and water preservation in key areas, treatment to water pollution in major rivers and reservoirs, treatment to over exploitation of underground water and protection herefor.

Increase of vegetation area for conservation of soil and water

Forestry could facilitate effective consolidation and improvement of soil, improvement of ground water conditions and water resource in general, and maintenance of sound ecological system. Hence, protection of water resource is inseparable from development of and support from forestry [7].

Greater attention shall be attached to implementation of key works to promote progress of forestation and greening works. The construction of forestry ecology shall be enhanced, which includes returning farmland to forestry, protection of natural forests, formation of protection forests and greening works in villages and townships. Tree planting activities shall be conducted voluntarily. Management shall be stepped up for forest cut quota and protection and utilization of forestry land. Cut of forest for commercial purpose shall be prohibited. Efforts shall be reinforced with regard to forest fire prevention, prevention of pests harmful to forestry, seedling plantation, security of forests, monitor over epidemic of pests and wide animals harmful to forests and other infrastructures. Through the works here above, water and soil could be protected effectively, soil erosion prevented and water resource conserved.

Increase of input in water saving funds

Conservation and protection of water resource is inseparable from financial support since water saving technology and facilities require a great deal funds which individual industry could not afford. Government shall increase input in conservation of agricultural and industrial water and in preservation of water in forests. Funds shall be put in priority into industries saving water or having low water consumption. Substantial support shall be given to develop water saving technologies. The public shall be encouraged to use more water saving equipment and technology [8].

Mobilization of social force to transform concept for water use

Water saving awareness shall be enhanced to water consumption bodies. Publicity and educational activities at different levels shall be conducted through different means. Television, internet, journal, radio and other medium shall be utilized to make water using and saving knowledge known to the public. In this way, the importance of water conservation together with danger of water shortage could be deep rooted into the heart of water users; negative effects to water due to unhealthy living manner be changed, habits of protecting water mains and saving water be cultivated and sense of danger and responsibility for water resource be enhanced. Public knowledge of return water shall be changed and mental obstacle for using return water be overcome. Public awareness of rain resource shall be improved, measures to use rain water be implemented and utilization rate of water resource improved. In this way, water could be conserved, harmony between man and water established and sustainable utilization of water resource in cities achieved. Development and promotion of water saving technology and tools is an important way to conserve water for general uses. For instance, the use of water saving faucets, toilets and washing utensils could reduce loss of domestic water. Moreover, the implementation of water saving policies shall be enhanced through laws and legislations, families be encouraged to use water saving appliances and water saving residential buildings be promoted to improve efficiency in using water. Government shall give more support for development and promotion of water saving technology and appliances and technologies and appliances consuming large amount of water shall be replaced step by step.

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